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Center for Army Analysis

VALUE ADDED ANALYSIS
NORTHEAST ASIA

DECEMBER 2003

CENTER FOR ARMY ANALYSIS
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13. ABSTRACT *(Maximum 200 Words)* This project was requested by the Office of the Deputy Chief of Staff, G8, Force Development. The purpose of the project was to evaluate the costs and benefits of selected weapon systems and to develop and evaluate alternative weapon system modernization programs. Value Added Analysis (VAA) analyzes benefits and costs among different weapon systems and munitions.			
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VALUE ADDED ANALYSIS NORTHEAST ASIA - QVNEA

SUMMARY

THE PROJECT PURPOSE was to evaluate the costs and benefits of selected combat systems and to develop and evaluate alternative weapon systems modernization programs.

THE PROJECT SPONSOR is the Office of the Deputy Chief of Staff, G8 (DAPR-FDA), Headquarters, Department of the Army.

THE PROJECT OBJECTIVES were to:

(1) Determine the marginal effectiveness of selected modernization weapon systems.

(2) Determine the procurement costs of the modernized systems.

(3) Develop and analyze alternative weapon systems modernization programs.

THE SCOPE OF THE PROJECT: With Training and Doctrine Command (TRADOC) approved Northeast Asia (NEA) 3.0 scenario using Vector in Commander (VIC) corps-level combat model, determine the effectiveness of modernized weapon systems as these systems compare to their base counterparts.

THE MAIN ASSUMPTION

(1) Combat simulations are an appropriate means of measuring weapon system combat effectiveness.

(2) The selected Measures of Effectiveness (MOE) adequately assess the combined utility of weapon systems under consideration.

(3) The TRADOC NEA scenario is appropriate to evaluate the weapon systems under consideration.

THE PRINCIPAL LIMITATIONS are**:**

(1) Not all procurement programs are analyzed because of the limitations of the corps combat model.

(2) Deployability, effects of training, and other readiness issues are not modeled.

(3) Cost Module does not include Operation and Maintenance cost.

THE PRINCIPAL FINDINGS are**:**

(1) The primary killer on the battlefield is the Comanche, the Crusader firing the Excalibur munitions, and then MLRS firing the MSTAR munition. These three systems all participate in the deep fight. The close-in fight is left mainly to the tanks, which performed admirably by eliminating the enemy tank, artillery, helicopter, and anti-tank (TAHA) systems that remain.

(2) One of the exciting aspects of this scenario is that there isn't a negative interaction between either of the artillery systems and the helicopters. In other words these systems are able to co-exist on the battlefield without reducing the effectiveness of each other, and should an enhanced capability be found to improve any of these systems, we can expect that capability will be fully exploited.

THE PROJECT EFFORT was conducted by LTC Al East, Resource Analysis Division, Center for Army Analysis (CAA)

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1 INTRODUCTION

1.1 Value Added Analysis – QVNEA

Headquarters, Department of the Army (HQDA), requires analysis to support the development of a balanced and effective modernization program. The Office of the Deputy Chief of Staff, G8, Force Development, requested this project. The purpose of the project is to identify and analyze marginal costs and benefits of weapon systems and develop feasible, affordable modernization investment strategies in support of defense reviews. In this case Value Added Analysis (VAA) was used in support of the POM (04-09). VAA analyzes benefits and costs among different weapon systems, sensors and munitions.

1.2 Background

The scenario used for this study is the Northeast Asia (NEA) 3.0 scenario. This simulation-modeling study used the Vector in Commander (VIC) model (the Army's principal corps-level simulation). VIC is a two-sided deterministic, discrete-event simulation of combat in a combined-arms environment representing land and air forces at the U.S. Army corps level with a commensurate enemy force in a mid-intensity battle. The model has variable resolution, portrays non-linear warfare, represents all air-land battle functions, and has been verified and validated by U.S. Army Training and Doctrine Command (TRADOC) schools and centers. The model is designed to provide a balanced representation of major force elements in a tactical campaign of a U.S. Army corps operating in a Theater of Operations.

1.3 Purpose

The Value Added Analysis framework consists of the following modules: issue definition, effectiveness, cost, and optimization. The purpose of this effort is to generate and provide combat-effectiveness data and cost-estimate data, and using optimization formulation to determine investment strategies. The end result will be used as a tool in the analysis that goes into the decision-making process for Program Objective Memorandum (POM) 04-09.

1.4 Key Assumptions

The key assumptions for VAA QVNEA are:

(1) Combat simulations are an appropriate means of measuring weapon system combat effectiveness.
(2) The Measure of Effectiveness (MOE) (which is the Fractional Exchange Ratio – FER) properly depicts the effectiveness of each weapon system. We use tanks, anti-tank vehicles, helicopters, and artillery (TAHA) when determining the FER.
(3) The TRADOC NEA 3.0 scenario is appropriate to evaluate the weapon systems under consideration. The scenario properly stresses the systems being analyzed to show how effective the systems actually are.

1.5 Key Limitations

The key limitations for VAA QVNEA are:

(1) Only one scenario and one timeframe are explicitly modeled.
(2) Not all procurement programs are analyzed because of a limitation of the corps combat model (Vector In Commander - VIC). VIC has a weakness in that it does not model Combat Support and Service Support well. The model focuses on the combat ability of systems. Because VIC is corps level, theater assets are not simulated well. This is evident when trying to simulate theater air defense systems – VIC is not a good tool to show the effectiveness of these systems.
(3) Deployability, effects of training, and other readiness issues are not modeled. Deployability is not modeled in VIC – the game turns on and the units are ready to fight (units can be delayed in entering the simulation, but once in – units are prepared to fight). The simulation is very sterile; all units with the same TOE have the same ability, all units ready to fight when simulation starts. VIC does not take training into account (Infantry Battalion A will be just as effective as Infantry Battalion B).
(4) Cost data is received from the Army Cost and Economic Analysis Center (CEAC). A shortcoming is that it does not provide O&M cost for all systems – particularly new and future systems that do not have data to support the O&M cost. This is an issue we are attempting to fix.

1.6 Scope

The scope of this report includes the 15 weapon systems and sensors presented in Figure 1. The sponsor of the project, the Army G8, determined what Army weapon systems to include in QVNEA. This report provides a comparison of the base systems as they compare to their modern counterparts.

	Base	Ammunition	Modern	Ammunition
1	AH-64D		RAH-66	
2	MLRS	I/IA/M26/ER & ATACMS	MLRS	MSTAR
3	Paladin	HE, DPICM, LCCM	Crusader	Excalibur
4	Sentinel		JLENS	
5	Guardrail		ACS	
6	Striker		Future Fist	
7	M1A1		M1A2	TERM
8	No UAV		TUAV	

Figure 1. Systems Analyzed

Also analyzed are the interactions between two systems. VAA identifies and analyzes all interactions between two systems. That interaction may include:

(1) Sensor and shooter.
(2) Direct and indirect fire systems.
(3) Two indirect fire systems.
(4) Two direct fire systems.

These interactions can be synergistic, anergistic, or negligible. Interactions between 3 or more weapon systems are not analyzed due to time and resource constraints.

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2 METHODOLOGY

2.1 VAA Methodology

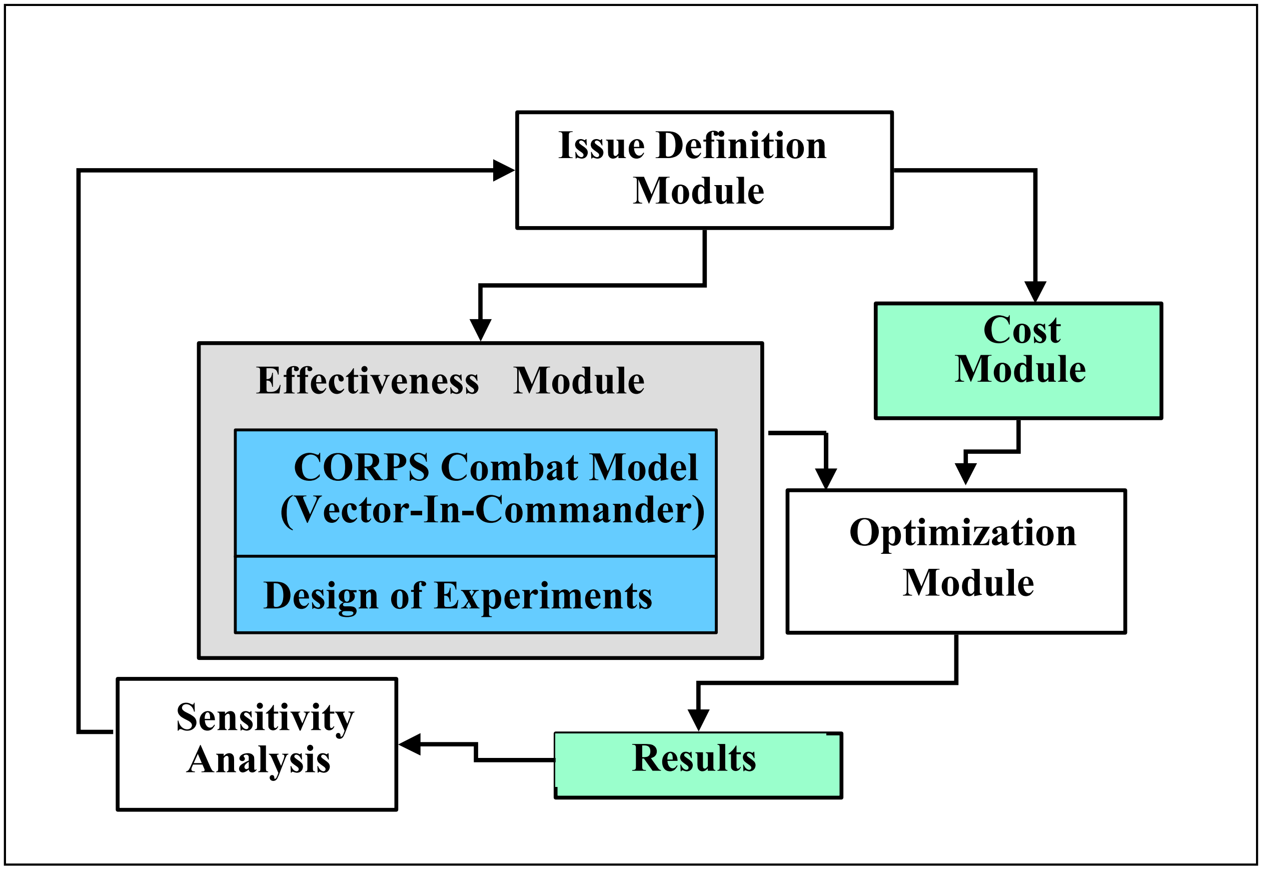
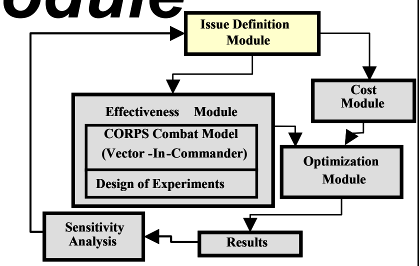


Figure 2. VAA Methodology

Figure 2 provides the framework of the Value Added Analysis (VAA) methodology. The VAA methodology was developed in the late 1980s to address the problem of cross mission area tradeoffs between modernization programs. It consists of a series of sub-analyses integrated into a methodology that culminates in the generation of recommended acquisition strategies. The conduct of a VAA study typically consists of an initial long-term project followed by a series of quick reaction analyses. The long-term project is designed to develop the cost and effectiveness information necessary to support the analysis of the issues in the current Program Objective Memorandum (POM) decision cycle. The follow-on quick reaction analyses then address specific questions and concerns. This report will discuss the long-term portion of the analysis.

2.2 Issue Definition Module

Issue Definition Module



- What are the cost and benefits of the...
  - Comanche compared to the Apache?
  - Crusader compared to the Paladin?
  - MSTAR compared to ATACMS?
  - ACS compared to the Guardrail?
  - Future Fist compared to the Striker?
  - M1A2SEP compared to the M1A1?
  - TUAV compared to no TUAV?
- What is the effect of bad weather in the NEA scenario on the measures of effectiveness?
- What are the synergies between systems in the NEA scenario?
- What are some good system investment strategies based upon both the SWA and NEA scenarios?

Figure 3. Issue Definition Module

The VAA procedure begins with the determination of the systems to be addressed in the current iteration of VAA. This list is developed in conjunction with the study sponsor. Figure 3 addresses questions that the sponsor requested to be analyzed. The issue-definition module requires that the problem be defined and its associated elements be studied so that the data collection and analysis efforts can be focused upon the questions and issues of interest to decision makers. The general context of the study in terms of systems and programs to be analyzed is established, along with timeframes and scenarios of interest.

Figure 1 provides the list of systems and munitions that were analyzed.

2.3 Effectiveness Module

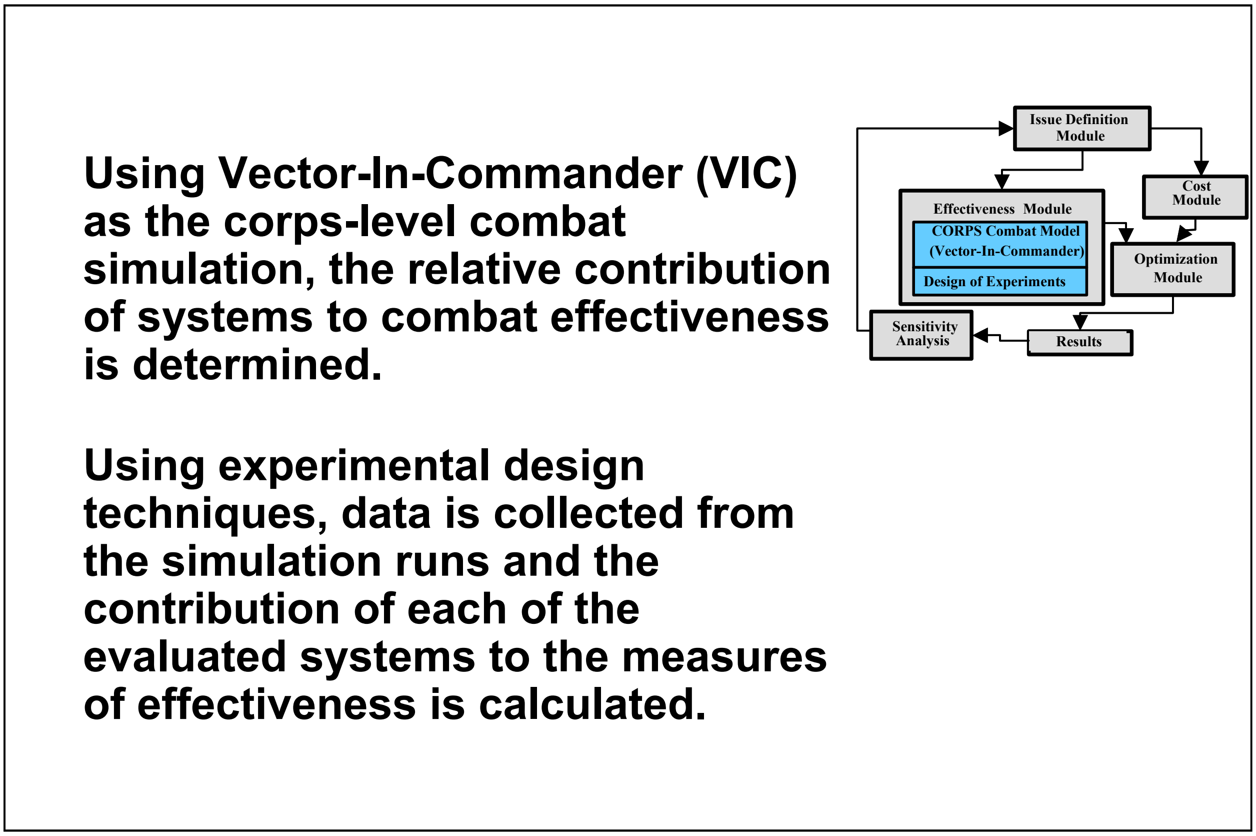


Figure 4. Effectiveness Module

The purpose of this effort is to generate and provide combat-effectiveness data for input into the VAA process. The modeling and analysis effort for the effectiveness module uses the Vector In Commander (VIC) model with a TRADOC-approved Northeast Asia (NEA) scenario in a 32 run design of experiment to calculate loss and force exchange ratios. These ratios form the main inputs into the effectiveness module of the VAA process.

The effectiveness module is the most time/resource intensive module in the analytical framework. The end result of this portion of the process is to generate the objective function for the mixed integer optimization program in the final section of the methodology. The first step in this module is to determine the design of experiment. The design of experiment was built to address the need to support a hypothesized set of predictor variables.

The run matrix of the design of experiment was created to support analysis of the eight treatment factors, named Helo, Tank, Rkt Arty, SP Arty, UAV, TUAV, Radar, Striker, and Guardrail in the context of least squares regression analysis. This regression model in generic form is:

$$y_i = \alpha + \sum_{j=1}^{m} \beta_j x_{ij} + \varepsilon_i$$

where i represents the observation number. The ε_i are modeled as statistically independent of the x's and each other, and randomly distributed according to a normal distribution with mean zero and variance σ^2. Under these assumptions, the regression coefficients are to be taken as unbiased indications of the effect of different equipment trades, but they are subject to estimation error due to sampling.

The design matrix (Figure 6) is a fractional factorial design, in which all combinations of four factors define the 32 runs, and the remaining four factors are obtained by multiplying various combinations of the four factors. The design matrix is balanced with respect to the hypothesized effects, and none of these hypothesized interaction effects are confounded or aliased. The matrix is chosen so that any two of the variables or products in the equation are uncorrelated and have a mean of zero. For example, if one forms the products of $ACSl_i$ with $MLRS_i*TUAV_i$ their sum will be zero over the experimental design. A consequence of this lack of correlation is that, for each of the levels of term A, the average value of term B is zero. This implies that MOE differences between the levels of A as seen in the raw data are unaffected by the value taken by the coefficient for any term, B. Because of this property, difference in the means of treatment groups are not misleading in view of the other treatment effects or interactions as long as these are among the hypothesized set. The regression coefficients will be exactly one-half of the observed differences.

- **Conduct base case runs to obtain consistent MOEs.**
- **Conduct switch analysis runs to test "value added" effect of new weapon systems.**
  - **One at at a time replacement for all systems.**
  - **Modify technical and operational data sets so the scenario results are credible.**
- **Conduct demonstration case runs IAW experimental design.**
  - **32 runs – combination of base systems and modern systems.**
  - **Modify technical and operational data sets so the scenario results are credible.**
  - **Identify ammunition contribution to system effectiveness.**

Figure 5. Design Methodology

The design methodology used for the effectiveness module is listed in Figure 5. A three-step process was used as it pertained to VIC runs.

Step one was to conduct the base case runs. After we were comfortable with the base runs (flow of the battle with the base systems) we conducted switch analysis. A modern system was substituted for a base system in VIC to determine if the data for the modern system enabled the system to perform as one would expect it to perform. This was done for each modernized system. Analysis was conducted on each of these runs to ensure the modernized systems performed as one would expect. If there were any questions reference the performance of the modernized system more analysis was conducted to determine if there were flaws in any of the data. Once we were satisfied with the base case/switch analysis, we then conducted the design of experiment (DOE) runs.

The Loss Exchange Ratio (LER) is the ratio of Red losses divided by Blue losses. Fractional Exchange Ratio (FER) is an indication of the likelihood that the Blue force wins or loses by measuring the fractional Red losses divided by fractional Blue losses, normalized for the size of each force. The data used in the LER/FER calculation was computed from the model's record of killer-victim interactions (the "Record 1" file from VIC output). These files were filtered in a controlled and auditable manner using the "SAS" statistical package. Thus the LER and FER were calculated directly from source data using an automated filtering mechanism.

Base System	**MLRS**	**Crusader**	**Apache (Mixed Force)**	**Sentinel**	**Guardrail**	**Striker**	**M1A1**	*no UAV*
Munition	Rockets & ATACMS	HE, DPICM, LCCM		(sensor)	(sensor)	(sensor)		(sensor)
00	-1	-1	-1	-1	-1	-1	-1	1
01	-1	-1	-1	-1	-1	1	1	-1
02	-1	-1	-1	-1	1	-1	1	-1
03	-1	-1	-1	-1	1	1	-1	1
04	-1	-1	-1	1	-1	-1	1	1
05	-1	-1	-1	1	-1	1	-1	-1
06	-1	-1	-1	1	1	-1	-1	-1
07	-1	-1	-1	1	1	1	1	1
08	-1	-1	1	-1	-1	-1	-1	-1
09	-1	-1	1	-1	-1	1	1	1
10	-1	-1	1	-1	1	-1	1	1
11	-1	-1	1	-1	1	1	-1	-1
12	-1	-1	1	1	-1	-1	1	-1
13	-1	-1	1	1	-1	1	-1	1
14	-1	-1	1	1	1	-1	-1	1
15	-1	-1	1	1	1	1	1	-1
16	1	1	-1	-1	-1	-1	-1	-1
17	1	1	-1	-1	-1	1	1	1
18	1	1	-1	-1	1	-1	1	1
19	1	1	-1	-1	1	1	-1	-1
20	1	1	-1	1	-1	-1	1	-1
21	1	1	-1	1	-1	1	-1	1
22	1	1	-1	1	1	-1	-1	1
23	1	1	-1	1	1	1	1	-1
24	1	1	1	-1	-1	-1	-1	1
25	1	1	1	-1	-1	1	1	-1
26	1	1	1	-1	1	-1	1	-1
27	1	1	1	-1	1	1	-1	1
28	1	1	1	1	-1	-1	1	1
29	1	1	1	1	-1	1	-1	-1
30	1	1	1	1	1	-1	-1	-1
31	1	1	1	1	1	1	1	1
MOD System	**MLRS**	**Crusader**	**Comanche (Pure)**	**JLENS**	**ACS**	**Future Fist**	**M1A2 SEP**	**TUAV**
Munition	MSTAR	Excalibur (3 variants)	Identical Munitions Mix	(sensor)	(sensor)	(sensor)	TERM	(sensor)

Figure 6. Design of Experiment

The design of experiments was determined using a Fractional Factorial design (Figure 6). We desire to determine the combat contribution of each system to the outcome of the battle as measured by the combat effectiveness MOE. A common method of accomplishing this task is to establish a baseline case, which includes no new system, then to add or substitute each new system one at a time, measuring the changes in combat effectiveness. These changes from the baseline case measure the contribution of a system. While this method measures the contribution of each individual system, it does not directly allow for the determination of the combined effect of systems mixes, i.e., if an attack helicopter raises the value of an MOE by x and a tank raises the value by y as individual substitutions, then it is often not true that if both systems are present, the resulting improvement would be $x + y$; it may be lower or higher.

The ideal method of determining the optimal mix of new systems would be to explore all possible combinations. This method would find the combination of systems that yields the greatest increase in the MOE values. While this method is practical for situations where the number of systems to be evaluated is small, the number of combinations grows quickly as the number of such systems increases. For three systems, there are 2^3, or eight combinations. If one had to explore every combination of 39 different systems, the number of potential runs would be 2^{39}, or about 5.5 billion runs.

Response Surface Methodology (RSM) represents a compromise between the process of replacing systems one at a time and the ideal solution of examining every combination. This compromise is known as a fractional design, meaning that a specific subset of the combinations is used. The subset of combinations of systems to be examined is determined using a particular experimental design. The resulting "design matrix" varies the combinations in an efficient manner so that a general linear model can be built to forecast the effects of the systems with respect to the outputs. A set of coefficients is computed which is the mean or average combination of the new system. These coefficients can then be used in an additive estimate.

Fractional Factorial designs are useful when the problem of determining the main effects with maximum precision is reduced to a combinatorial problem. They are useful when the problem has only two level factors, i.e., when there are low and high variable settings or binary (0, 1) variables. In VAA, the systems being considered for procurement are the "*factors*". A "1" represents the presence, in the appropriate quantities for the modeled force structure, in the excursion. A "-1" indicates that the Base Case Systems are played in that excursion.

The DOE was made up of direct fire systems, indirect-fire systems, munitions, and sensors. This straightforward design clarifies in understanding scenario dynamics and exactly how these systems stack up against one another. An understanding how C4ISR information travels and is used is difficult to ascertain. Usually we can understand information flow and dynamics by looking at sensor configuration, and then running sensitivity analyses to understand sensor *effects*. These *effects* are what we see manifest in the DOE, but directly measuring sensors or viewing their dynamics remains veiled.

During the battle it is noticed that the helicopters dominate the killing. Artillery systems kill the next most (MLRS being the primary contributor). The contribution of the Excalibur munition is clearly visible when it is played in Crusader. And finally, we see tanks playing some sort of "shock absorbing" role that seems to react to the effectiveness of the other systems.

As we reflect upon this, it is quickly recognized that we are witnessing a textbook case of the combined arms fight! Our sensor systems are able to detect their targets at a distance, and depending on the effectiveness of the killer system in place (Comanche/MSTAR munition/Excalibur munition being the most effective), we fight the deep battle well. As Blue mechanized forces meet the Red forces for the close battle, we see Blue tanks able to defeat whatever remaining forces are present.

It is with this understanding that the following results should be understood. Blue forces have the information advantage. More often than not, we also have that information directly paired to a shooter. An important lesson learned from this analysis is just that. When we don't have a shooter paired with a sensor, that information is useless. A corollary of that rule is when we have a shooter in the DOE without the best intelligence assets available, that shooter is not working at its full potential. It is in this sense then, that we, perhaps for the first time, clearly see the importance of information, and most importantly, the marriage of the correct kind of information with a shooter to whom it is useful.

This scenario coupled with this DOE provides clear insight into the way the combined-arms fight is supposed to work in the real world. The dynamics between the four shooters (Crusader, MLRS, helicopters, tanks) demonstrate killing at a distance in a coordinated fashion, which was then followed up with the close in fight.

One of the exciting aspects of this scenario was that there wasn't a negative interaction between either of the artillery systems and the helicopters. In other words these systems were able to co-exist on the battlefield without reducing the effectiveness of each other, and should, an enhanced capability be found to improve any of these systems, we could expect that capability would be fully exploited.

When it came to sensors we saw a different situation due to the nature of what sensors bring to the battlefield (i.e. information vs. steel). In the case of sensors we saw the marginal utility of additional information was reduced as we approach "unity" or perfect knowledge. In the case of NEA 3.0, we saw that the intent according to the OPLAN was to model a digitized corps. To a great degree, the scenario succeeded in doing that; thus it is difficult to demonstrate the utility of yet more knowledge to the battlefield because this was redundant knowledge.

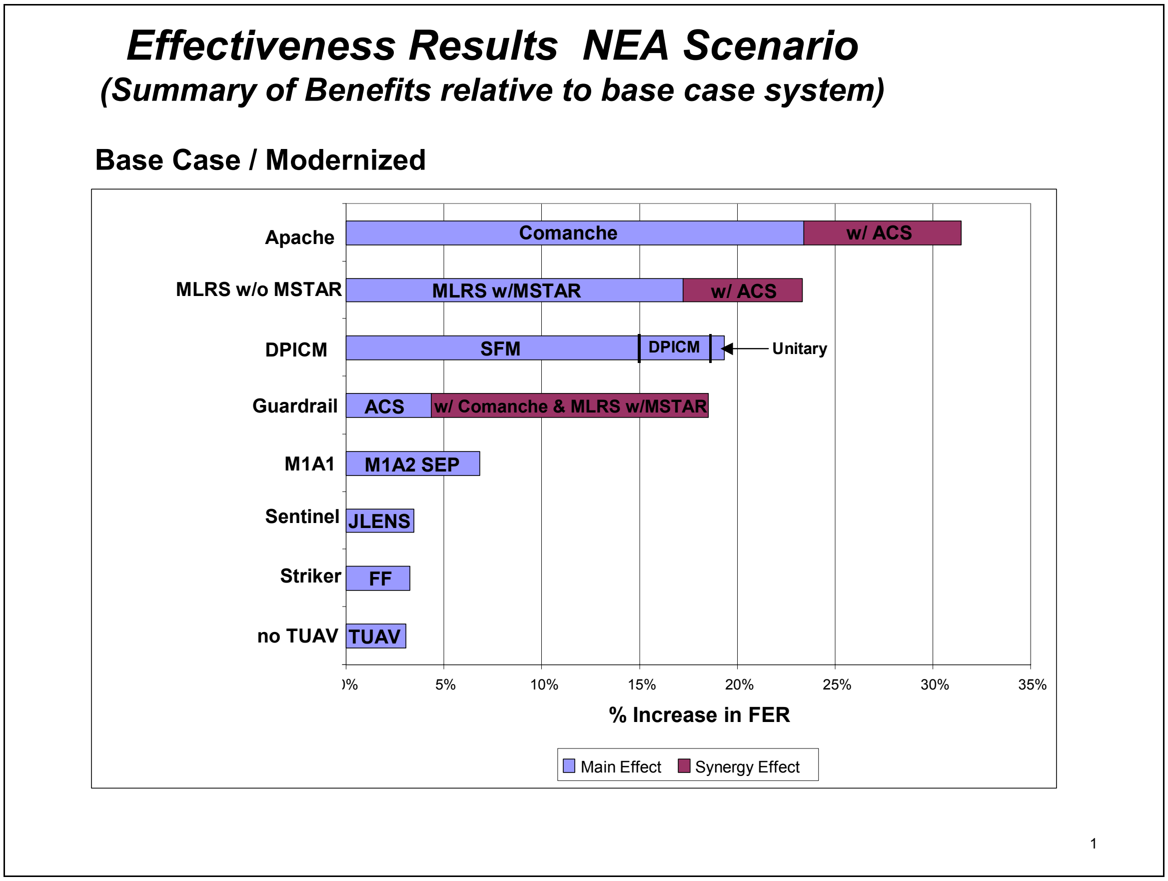


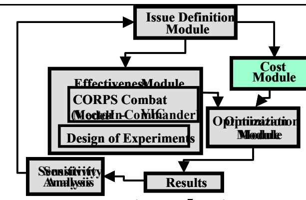
Figure 7. Increase in Fractional Exchange Ratio

After completion of the DOE runs, analysis was conducted to determine the fractional exchange ratio for each run. Regression analysis was then conducted on each run to determine the percent increase for each modern system. Figure 7 represents the percent increase as it pertains to the fractional exchange ratio for the modern systems compared to the base systems.

Also shown is the significant synergy effect between systems. There were two interactions that had a significant effect – Comanche/ACS and MRLS with MSTAR/ACS. The percent increase in the fractional exchange ratio for this synergy is shown in Figure 7.

2.4 Cost Module

Cost Module



- ❑ **Life cycle costs are estimated using the most accurate data available from the Army Cost and Economic Analysis Center (CEAC).**
- ❑ **Life cycle costs included:**
  - **Research, development, test, and evaluation (RDT&E) costs.**
  - **Fixed production costs.**
  - **Variable production costs, to include learning curve effects.**
  - **Operations and maintenance costs.**
- ❑ **The annual RDA appropriation is estimated from a base planning document and used to constrain procurement expenditures for a given year.**

Figure 8. Cost Module

The purpose for the cost module is twofold. First, accurate system procurement costs must be estimated, including research, development, test and evaluation (RDT&E) costs; fixed production costs; and variable production costs. These costs are necessary for conducting the optimization that finds the mix of systems that maximizes the effectiveness of the force subject to constraints on the Research, Development, and Acquisition (RDA) budget. Second, given optimization quantities of procured systems, estimates must be computed of the other aspects of the life cycle costs of the system. These aspects include fielding costs, containment costs, and facilities costs. Once the various components of the life cycle costs are computed, they must be made available in an easily accessible form so that information regarding the costs of the modern systems can be analyzed.

An important aspect of estimating the procurement costs associated with the modern systems is determining whether or not a significant relationship exists between the unit cost of a system and the quantity procured. For many of the modern systems, particularly the developmental systems that involve new technology (such as the RAH66 Comanche), this cost-quantity relation is significant and nonlinear. As such, this relationship must be considered and accounted for to ensure accurate results. For the purposes of this study, the cost-quantity relationship reflects economies of scale in terms of materials and labor, as well as “learning” on the part of production labor force. The Army Cost and Economic Analysis Center generated the cost data that included the following:

1.0 - Total RDT&E by year cost in same year constant dollar;
2.0 - By year cost in same year constant dollar spread by year for each sub-element (2.01 to 2.14) production quantity by year; and,
5.0 - Total OMA by year cost in same year constant dollar, and breakout by:
 * 5.03 - Consumables
 * 5.04 - Reparables
 * 5.05 - POL

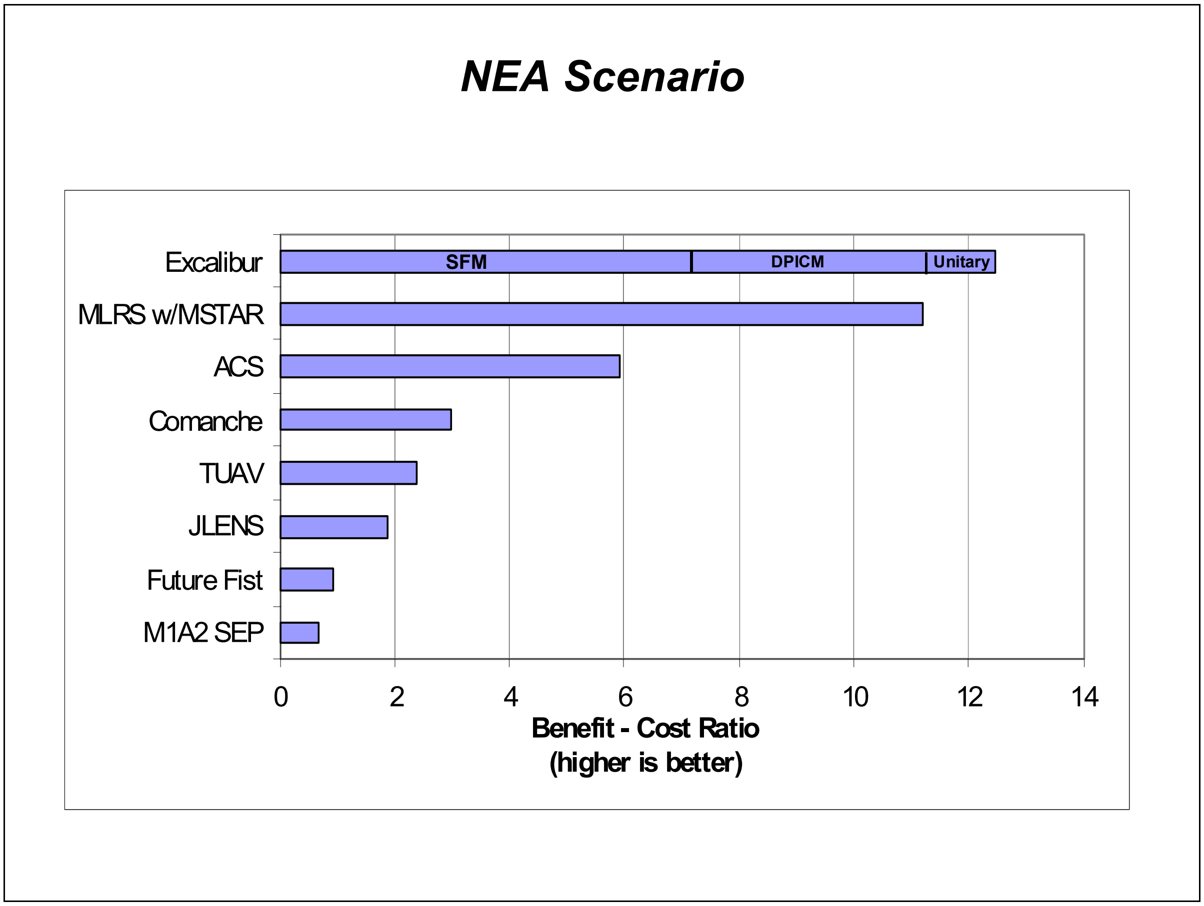


Figure 9. Benefit Cost Ratio

Cost estimates are completed for each modern system. The effectiveness per system (percent increase in FER) is then divided by the cost per system to determine the "Benefit-Cost Ratio". Figure 9 depicts the "Benefit-Cost Ratio" for this study. The phrase "Most Bang for the Buck" is often used for this outcome. It was determined that the Excalibur provided the "Most Bang for the Buck" for this scenario. One must understand that the results are for a certain scenario and may change in a different setting/scenario.

2.5 Optimization Module

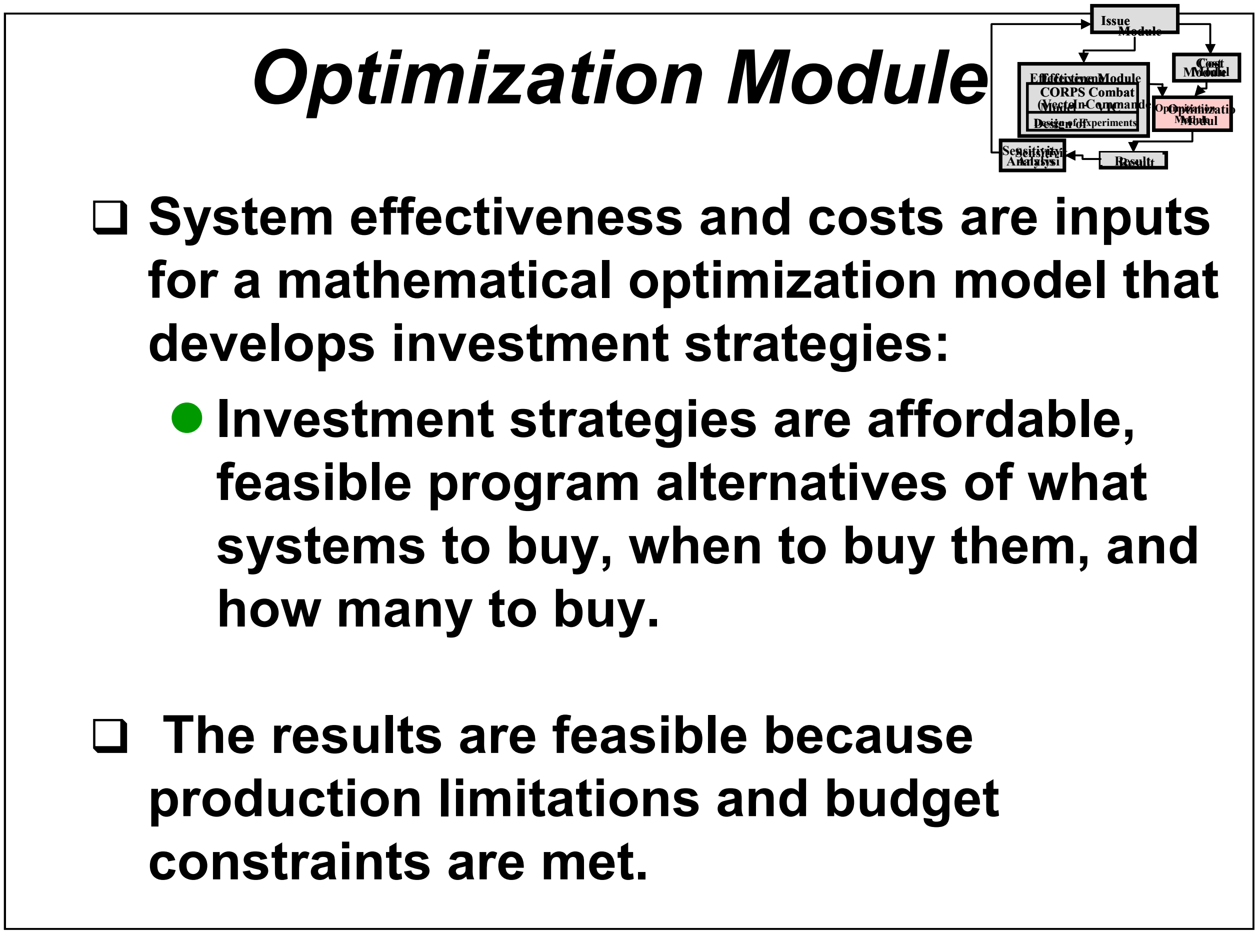


Figure 10. Optimization Module

The optimization module generates several acquisition strategies for the systems under consideration. This acquisition strategy is obtained from a mixed integer, linear programming optimization model, with the objective of maximizing the total effectiveness of the Army, as generated in the effectiveness module discussed earlier. This objective is constrained to meet the requirements of staying within the total obligation authority allocated to the systems under consideration, meeting the fielding goals obtained from the Army G8, staying within the ability of the production lines to produce the equipment, and finally taking any industrial base concerns into consideration.

There are several variables that are fed into the optimization module. The following provides the variables with definition:

Fixed Costs: Any cost that is incurred by a program that is not related to the quantity of the item produced is designated a fixed cost. The model considers two such categories of cost. The first is Research, Development, Test, and Evaluation (RDTE) costs. These costs are typically incurred during the POM period, and, as the name implies, pay for many of the developmental aspects of the procurement programs. The other category is that of fixed production costs. These costs are incurred just prior to, and early in the production phase of, the funding profile for the programs. These costs are incurred irrespective of the quantity produced. Any line closing costs at the conclusion of the production of the program are also represented as fixed costs. All of the fixed costs are summed for each year and are assessed against the program if the program is selected for funding.

Variable Production Costs: The costs associated with the production of an individual item are designated as variable costs. These costs are also represented in two ways. The first concerns items for which there is no change in the cost as a function of the quantity produced. This means there is no learning behavior that is identifiable in the per-unit cost of the item for the entire cost, or for some component of the cost. In this case, an average unit cost is given and is assessed for each item produced. The second concerns items that do exhibit an identifiable learning behavior in their variable costs.

Force Structure Requirements: Force structure requirements drive the decisions regarding how many of a particular item of equipment should be procured. For each candidate program, the study sponsor must specify the level of force structure that is to be modernized with the candidate system. The specification might be in terms of force packages to be modernized, in terms of some other grouping of units, or as a total number of items to be procured. Often the sponsor will specify the exact program with respect to the years of procurement and the yearly procurement quantities. The optimization model is flexible enough to handle any of these methods of specifying total required quantities for the candidate systems.

Production Limitations: An important aspect of the VAA methodology is the computation of a feasible acquisition strategy for each of the funded candidate/modernized systems. To ensure feasibility, the ability of industry to produce the specified quantity in each year of the production campaign of each funded program is accounted. Thus, the yearly production quantities must be constrained to be between the minimum sustaining rate of production and the maximum production rate of production. These values which are provided as data represent the output of one 8-hour shift and three 8-hour shifts, respectively, of the specified production facility for the given candidate system. Additionally, initial quantities are often ramped up in the early years of production. These restrictions are handled in the same way as the other production constraints. Finally, a fairly smooth production campaign is usually desirable. This means that large swings in yearly production quantities cannot be permitted. So limits must be placed on the quantities such that the procurement quantity for a system in one year must not vary from the previous year’s quantity by more than some allowable percentage. This percentage is specified as input data to the optimization program. Note that cost analysis estimates are made with respect to a particular production facility, and departures from the specified set of facilities would result in the need to reevaluate the program. Note also that when the sponsor specifies the program with respect to both the quantities and the years of procurement, both the upper and lower production limits are set to the given yearly quantity values, ensuring that quantities procured match the sponsor’s decision. The total quantity to be procured must match the force structure requirement values or infeasibility will result.

For this study the optimization module was not used do to the analysis required by the sponsor.

2.6 Resources

- Vector-In-Commander (TRAC-FLVN), Corps Level combat simulation.
- Continued funding for the contractor to perform combat simulation support to model scenarios.
- CEAC/CAA cost data support.

Figure 11. Resources

Resources from outside of the Center for Army Analysis that were required to conduct VAA are listed in Figure 11. Without these resources this study would not have been accomplished in the allotted time. By receiving the scenario, model and data from the TRADOC Analysis Center, Fort Leavenworth, we saved approximately one year of time/effort. This enabled the quick turn-around of analysis.

Northrop Grumman provided a team that set up and conducted all the VIC runs. They also played a major role in conducting the analysis for this project.

Cost estimates for each system were provided by the Army Cost and Economic Analysis Center (CEAC).

3 SUMMARY AND CONCLUSIONS

3.1 Summary and Conclusions

The use of Value Added Analysis provides decision makers at the Department of Army level with a tool to quickly evaluate programming and budgeting decisions in the area of system modernization.

Initial findings for this study determined that all the modern systems were in some way more effective than their base counterpart. The primary killer on the battlefield was the Comanche, the Crusader firing the Excalibur munitions, and then MLRS firing the MSTAR munition. These three systems all participated in the deep fight. System effectiveness was increased significantly when the ACS worked together with both the Comanche and the MLRS with MSTAR. The close-in fight was mainly left to the tanks, which performed admirably by eliminating enemy TAHA that remained.

Value Added Analysis provides rigorous analysis that supports the Army's modernization system. It has limitations, mainly that it does not cover all systems. VAA provides insights into modernization issues and provides viable, defendable options useable by the Army leadership as another tool in their decision making process.

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APPENDIX A PROJECT CONTRIBUTORS

1. PROJECT TEAM

a. Project Director:

LTC Al East, Resource Analysis Division

b. Team Members:

c. Other Contributors:

LTC John Gregory Heck, Documentation

2. PRODUCT REVIEWERS

Dr. Ralph E. Johnson, Quality Assurance

3. EXTERNAL CONTRIBUTORS (If any)

Northrop Grumman Information Technology

Mr. Joseph Gordon, United States Army Cost and Economic Analysis Center (CEAC)

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APPENDIX B REQUEST FOR ANALYTICAL SUPPORT

P A R T 1

Performing Division: RA ***Account Number:*** **2001165**

Acronym: **QVNEA** ***Mode (Contract-Yes/No):*** In-house

Title: Value Added Analysis NEA

Start Date: 09-Jul-01 ***Estimated Completion Date:*** 31-Oct-01

Requestor/Sponsor (i.e., DCSOPS): DCSPRO ***Sponsor Division:*** FD

Resource Estimates: ***a. Estimated PSM:*** 24 ***b. Estimated Funds:*** $0.00

c. Models to be Used: **VIC & VAA optimizer**

Description/Abstract:

Provide decision makers an analytical approach for the evaluation and prioritization of competing alternatives to support the development of a balanced and effective Army research, development, and acquisition (RDA) program. Analyze different modernization alternatives for the QDR and POM and compare them to a baseline of Army systems with respect to cost, effectiveness, and other measures using a Northeast Asia corps-level scenario.

Study Director/POC Signature: Phone#: 703-806-5391

Study Director/POC: **LTC Al East**

P A R T 2

Background:

Headquarters, Department of the Army (HQDA) requires analysis to support the development of a balanced and effective modernization program. Value Added Analysis (VAA) analyzes benefits and costs among different weapon systems and munitions.

Scope: Northeast Asia (NEA) scenario using Vector-In-Commander corps-level combat simulation for the combat effectiveness module.

Issues: Selecting appropriate weapon systems for analysis; identifying relevant measures of effectiveness; determining optimal investments strategies.

Milestones: Completion of combat effectiveness, cost, and optimization modules.

Signatures ***Division Chief Signature: Date:*** **Signed and Dated**

Division Chief Concurrence: **Signed and Dated**

Sponsor Signature: **Signed and Dated**

Sponsor Concurrence (COL/DA Div Chief/GO/SES) : **Signed and Dated**

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APPENDIX C GLOSSARY

ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

ACS	Aerial Common Sensor
ATACMS	Army Tactical Missile System
CAA	Center for Army Analysis
CEAC	U.S. Army Cost and Economic Analysis Center
CGS	Common Ground System
DCGS	Distributed Common Ground System
DOE	Design of Experiments
DPICM	Dual-Purpose Improved Conventional Munitions
FER	Fractional Exchange Ratio
FF	Future Fist
HE	High Explosive
HIMARS	High Mobility Artillery Rocket System
JLENS	Joint Land Cruise Missile Defense Elevated Netted Sensors System
LCCM	Low Cost Competent Munitions
LER	Lost Exchange Ratio
M1A2Sep	M1A2 Abrams Main Battle Tank Systems Enhanced Package
MLRS	Multiple Launch Rocket System
MSTAR	MLRS Smart Tactical Rocket
MOE	Measure Of Effectiveness
NEA	Northeast Asia
OMA	Operations & Maintenance, Army
PGMM	Precision Guided Mortar Munition
POL	Petroleum, Oil, Lubricants
POM	Program Objective Memorandum
RDA	Research, Development, Acquisition
SEP	Systems Enhanced Package
SFM	Sensor Fused Munitions

RDT&E	Research, Development, Test, and Evaluation
SWA	South West Asia
TAHA	Tanks, Anti-tank vehicles, Helicopters, Artillery
TERM	Tank Extended Range Munitions
TRAC	TRADOC Analysis Center
TRAC FLVN	TRADOC Analysis Center Fort Leavenworth
TRADOC	Training And Doctrine Command
TUAV	Tactical Unmanned Aerial Vehicle
UAV	Unmanned Aerial Vehicle
VAA	Value Added Analysis
VIC	Vector In Command